Responses of *Gambusia affinis* to Changes in Hydrologic Regimes in Waller Creek, Texas

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Figure 1: A picture of *G. affinis*, the mosquito fish.

Great Global Environmental Threats

One of the many major issues that humans will have to face in the coming generations is the collapse of global fisheries. Important river dwelling and anadromous food fish like trout and salmon are being fished at an unsustainable rate.[1,2] We now see that many fisheries are overexploited or fully exploited.[3] To help save these species, it is required to gain knowledge about their biology and ecology so that we may better understand our impact on their populations. As such, one important field of study is how populations of fish respond to storm events. By better understanding fish movement, we may be able to improve upon existing dispersal models to determine the threshold of removal before population dynamics begin to shift. However, despite the importance of fish response to storm events, it is rarely studied.

Another issue we face in the next decade is the loss of biodiversity. Species are going extinct about a thousand times faster than what is considered natural, at least in part, to anthropogenic factors.[4,5] One of the more important sources of biodiversity loss is from invasive species, which have been shown to colonize new habitats quite quickly due to lack of predation. Studying the movement of invasive species is important in showing exactly how those species are able to colonize new habitat so quickly.

Gambusia affinis, the Mosquito Fish

One of the most invasive species on the planet lives in Waller Creek, a small creek running through the University of Texas at Austin campus. The species is called *Gambusia affinis*, or the mosquito fish.[6,7,8] The mosquito fish is originally from the Midwest United States, but has been transplanted all around the world by humans attempting to control mosquito problems. The mosquito

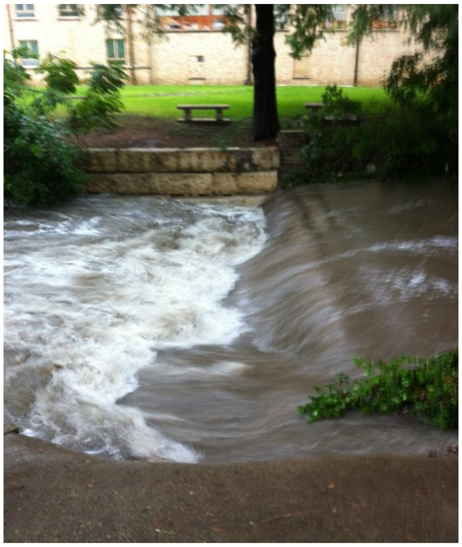

Figure 2: A flood of Waller Creek in Austin, Texas. The discharge is orders of magnitude above base flow.

fish is heralded as one of the greatest biological tools against mosquitos and is effective in controlling known malaria-vector mosquitos in some places,[10, 11] although not in all places.[12] However, the mosquito fish is also very resilient and a generalist when it comes to food, so it is able to thrive in virtually all areas and outcompete local fish. The mosquito fish has been carried from the Midwest to every continent in the world with mosquitos, and has devastated local food webs wherever it goes.[13,14]

The Effects of Flooding

My research began with a simple question: what happens to fish in the creek when it rains? Do they get flushed out or do they hide? The two competing ideas on this subject are:

1. Locally, fish find someplace to hide along the slower flowing edges of the creek, in pools or in spaces in the rocky benthos, so they don't move very far.
2. On a larger spatial scale, large storms are capable of moving fish great distances. They can move so far that they can be geographically isolated from the populations from whence they came.

The first concept comes from river ecology and demonstrates fishes' reaction to move to slower flowing areas of the river as current increases from a storm,[15] while the second comes from studies in evolution as a method of allopatric speciation.[16] These two ideas offer two completely different outcomes of storm surges. The importance of each factor in urban streams has not yet been effectively demonstrated. Urban streams are especially interesting because of how fast the current increases in a storm. During storm events, rain water meets impervious cement cover instead of soil and is channeled as runoff into local bodies of water. Urban streams can receive significantly more runoff than natural streams simply due to the vast area of cement to channel water into the creek. Thus, storm surges in urban creeks are far more dramatic than in natural creeks and result in higher and much more variable flows than a natural stream.

Taking Stock of Fish

To get a better idea of how fish move in response to storm events, a simple count of standing fish stock at various locations along Waller Creek were taken once every two weeks from 2:00pm to 4:00pm. The five stations were: the 32nd Street bridge, Eastwoods Park, the Creekside bridge, the 24th Street bridge, and the San Jacinto Dormitory drainage area. The visual count of fish is non-invasive and has no environmental impact. Special attention was paid to weather maps and the amount of precipitation delivered to the Waller Creek watershed in each two-week interval. Movement was determined from analyzing the relative abundances of Gambusia affinis at each site before and after storm events. Because dams exist between all sites, it is assumed that fish can only move downstream from their original position. It is also assumed that all fish in the creek move downstream with a storm. To validate this second assumption, fish similar in size and larger than G. affinis were also included in the determination of standing stock and measured for movement in response to storms.

Results: When It Rains, It Pours

It was found that fish in an urban creek are pushed downstream different distances during storm events based on the size of the storm event and on the size of the fish. Storms that were considered "large" (more than 8 cm of rain over the course of the event) pushed all sizes of fish considerably farther than storms considered "moderate" (4-8 cm of rain). In some cases, so much of a population can be pushed downstream that the new standing stock in the original area can be undetectable (Figure 3).

It was also found that larger fish are moved less during the same storm event as smaller fish. The larger *Lepomis spp* moved much less than the smaller *G. affinis* during storm events of the same magnitude.

The Ecological Implications

The results, while seemingly intuitive,

carry heavy implications for how we think about populations in river and stream communities. While rain events do not noticeably move larger fish like many species of sport fish or commercially important river fish, storms can move their prey. It can be inferred from the results that water-borne insect larvae will also be pushed by storms, so all types of prey are thought to move with storm surges. While the effect of moved prey on larger fish was not specifically studied, it has been shown that movements in prey can affect the ecology of predators.[17] Storm events thus place some stress on larger species of fish even though the fish themselves are not relocated downstream. This stress may play a part in reproductive success of the fish, which would affect the number of fish that could safely be removed from a population before the population is affected, although more study is needed to test this hypothesis.

The ability of smaller fish to move in response to storm surges also carries implications for the movements and dispersal of smaller invasive species like *G. affinis*. While research has been done to show that the eggs of river fish can travel downstream with the current,[18] this new research shows how sexually mature adults can also travel downstream, and can even travel over small dams. Sexually mature fish that travel downstream may spawn and disperse eggs even farther downstream than if the mature fish had not been moved. This changes the way that we think about dispersal in that invasive species in rivers may be capable of spreading downstream much faster than current models predict due to sexually mature adults of a relatively small species being relocated downstream. With this knowledge, we can gain a better

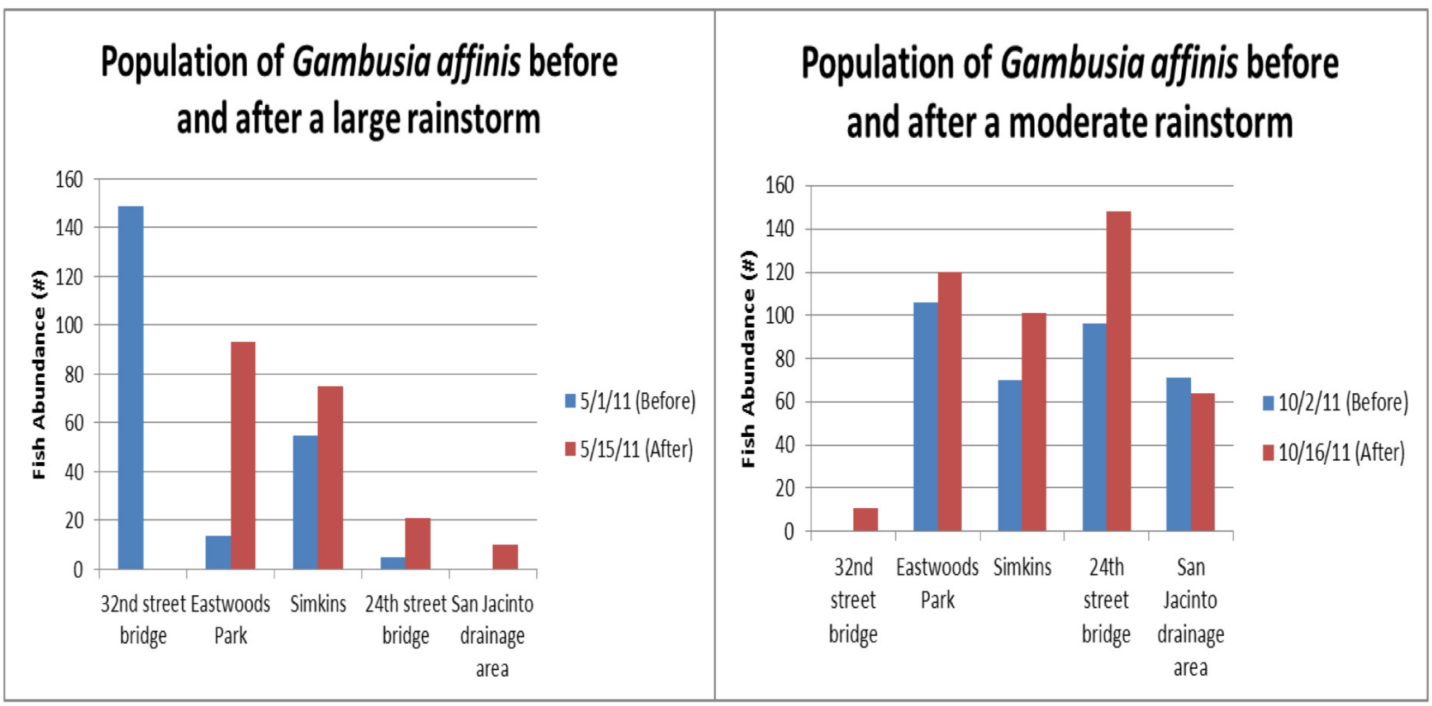

Figure 3: The populations of *G. affinis* after a large (>8cm)

understanding of the dispersal of invasive species and possibly learn better ways to contain them.

This research also highlights the compatibility of the two competing ideas of what happens to fish during storms presented above; they are not necessarily mutually exclusive. While it is certainly common for fish to hide in pools or crevices during storms to avoid being relocated, it is also possible for a large enough storm surge to move large portions of a population downstream. Because larger fish are not affected as dramatically as smaller fish, it is tempting to conclude that larger fish can resist storms because of their sheer weight. This may not be so, however, it may also be possible that larger fishes are capable of protecting territory that offers prime hiding spots or that they bully smaller fish out of hiding places. That larger fish are less affected by storms is an interesting finding and one that requires much more study.

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